RE - LS
FOREST SURVEY
General

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ALLOWABLE CUT

T.01

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Allowable cut is defined as the quantity of merchantable timber that may be cut annually during the next 10 years while maintaining or building up toward a desirable level of growing stock (per acre) and effecting a reasonably even distribution of size classes during the rotation selected for each type.

The allowable cut will be determined partly in the field and partly in the office:

Field job.--Partial cuts in mature uneven-aged stands and thinnings, intermediate cuts, and salvage operations in all stands. This portion of the cut will be determined on the sample plots as they are taken in the field.

All cuts will be kept within the limits of practicable operations. The minimum cut will be 1,500 board feet or the equivalent of 3 cords per acre of marketable timber. Marketable timber includes saw timber of all species and pole-size jack pine, spruce, balsam fir, tamarack, cedar, and aspen.

Office job.--The harvest cuts for even-aged types that will control the size-class distribution in the next rotation, but will not affect the stocking except to insure regeneration of the type. This portion of the cut will be computed in the office after data on type area, volume, and growth become available.

I. Field Job

Insofar as possible the determination of allowable cut will be handled on the ground as a part of the inventory work. First, all undesirable growing stock will be recommended for removal in an improvement or salvage cut. Second, excess desirable growing stock may be recommended for removal in a thinning or liberation cut.

1/ Maintained by the U.S. Department of Agriculture, Forest Service, in cooperation with the University of Minnesota, at University Farm, St. Paul, Minnesota.

A. The Improvement Cut

All trees 5 inches and over d.b.h. on each plot will be tallied by diagonal lines through the volume numbers (if desirable growing stock) or by circles around the numbers (if undesirable, that is, Class C). The growing stock classification system is given in the appendix. The same volume number may be used twice--once marked through and once circled. The cumulative volume of desirable and undesirable growing stock will be added together in calculating volumes.

B. The Thinning Cut

The basal area of well-stocked stands will be computed and compared with recommended growing stock levels to determine whether or not thinning is needed.

Rotation ages (table 1) and growing stock levels (table 2) are presented herewith. Rigid adherence to these ages and levels is not desirable. The optimum level is recommended for intensive management requiring frequent thinnings. The Forest Survey will use the standard level as best suited for extensive management.

The field crews may occasionally recommend cutting below the standard level in order to obtain a practical cut, but should never recommend reducing desirable growing stock below the minimum level.

The actual growing stock level for a plot and the average d.b.h. may be calculated as follows:

(a) Count the number of diagonal marks (desirable growing stock trees) by diameter classes. For the present these may be recorded in the left margin of the tally form below diagonal lines, opposite each diameter class.

(b) Look up the corresponding basal area for those numbers in the cumulative basal area table (table 4). These figures may be placed over each diagonal line in the left margin.

(c) Add basal area figures to obtain total basal area per acre for comparison with the recommended growing stock levels (table 2).

(d) In order to enter table 2, the average d.b.h. must be known. It may be easily computed by dividing the total basal area per acre by total number of trees per acre and translating average basal area per tree back to average d.b.h. The number of trees per acre may be computed by adding the products of number of 2- and 4-inch trees x 50, and number of larger trees x 5. The average d.b.h. for trees of various average basal area may be looked up in the block at the bottom of the basal area table (table 4).

If the actual growing stock exceeds the standard growing stock level, additional trees may be marked for cutting until the desired level is reached. Usually Class B trees will be marked for such thinning of the stand. They may be tallied by underlining volume numbers already crossed by diagonal lines. The cumulative volumes of Class C (circled) and "thin" (underlined) trees (if any) will be added to obtain recommended cut. After reducing for defect, net volume per acre may be summarized by species on the tally form.

II. Office Job

The net volume recommended in cuts exceeding 1,500 board feet or 3 cords per acre of marketable species will be summarized in the office. The net volume will be divided by the cutting cycle (table 1) to put the cut on an annual basis. Summarization by condition classes (including the volumes for harvest cuts) will provide the total annual allowable cut volumes by species.

The cuts of less than 1,500 board feet or 3 cords per acre of marketable timber may also be summarized in the same way, to show the additional volume that is available but not practical in regular logging operations.

The simple method described above for immature and uneven-aged stands is not suitable for calculating the harvest cut in even-aged stands. In the latter case, partial area control is needed. It is provided in the following basic formula:

$$H.C. = \frac{V + \frac{Gn}{2}}{n} \quad \text{or,} \quad = \frac{V}{n} + \frac{G}{2}$$

Where

H.C. = annual harvest cut
V = volume of timber in the mature size class
G = annual growth of the mature size class
n = liquidation period of the mature size class.

In some cases a part of the next lower size class will be harvested within the first 10-year period. This will be necessary when the first size class will be exhausted in less than 10 years.

$$\text{Then } H.C. = \frac{n}{10}\left[\frac{V}{n} + \frac{G}{2}\right] + \frac{10 - n}{10}\left[\frac{V^1}{n^1} + \frac{G^1}{2}\left(\frac{n + 10}{n^1}\right)\right]$$

$$\text{or} = \frac{n}{10}\left[\frac{V}{n} + \frac{G}{2}\right] + \frac{10 - n}{10}\left[\frac{V^1 + G^1\left(\frac{n + 10}{2}\right)}{n^1}\right]$$

Where

V^1 = volume of timber in the next lower size class
G^1 = annual growth of the next lower size class
n^1 = liquidation period of the next lower size class
n = liquidation period of the mature size class.

Volume and growth will be determined by the inventory. The liquidation period will be calculated by a modified area control method.

Rigid application of area control would often require cutting unmerchantable size classes or holding mature timber until it deteriorated on the stump. To avoid this, a harvest range must be set up for each even-aged type (table 1). The lower limit would be the average minimum age required to produce the desired products. The upper limit would be the average maximum age that overmature timber could be held without appreciable losses. These limits will depend upon the mean site quality of the area.

The liquidation period of any size class will depend upon the desired size-class distribution and the harvest range. Under strict area control:

$$n = P\left[\frac{R}{100}\right]$$

Where
n = the liquidation period (for rigid area control)
P = the percent of the type area covered by the size class
R = the optimum rotation age as determined by the mean site quality and the products desired

The minimum liquidation period is:

$$n_1 = R_1 - Ar$$

Where
n_1 = the minimum liquidation period
R_1 = the lower limit of the harvest range
Ar = the upper limit of age of the next lower size class

Here the formula shows the shortest possible time in which it will be possible to begin harvesting the next lower size class.

The maximum liquidation period is:

$$n_2 = R_2 - Ar$$

Where
n_2 = the maximum liquidation period
R_2 = the upper limit of the harvest range
Ar = the upper limit of age of the next lower size class

Here the formula shows the longest period of time that it is possible to defer harvesting the next lower size class.

Since size class adjustment is one of the primary goals, the rigid area control method should be used when it falls between the two extremes, provided by n_1, the minimum, and n_2, the maximum period. If it falls below the minimum, the minimum should be used. If it falls above the maximum, the maximum should be used.

Reasonable care in selecting the areas to be cut in any one year of the liquidation period will minimize the fluctuation in the volume of the cut. Since an effort is being made to improve the forest, the cut will increase over a long period until the ideal forest is reached. In the rare situation where an extremely even annual cut is mandatory, the area to be cut each year could be varied. In a near normal forest this would postpone the size-class adjustment. In an abnormal forest, a rigid volume control could destroy the forest by overcutting young stands or by undercutting mature stands.

Example 1.--Determination of the period of liquidation is illustrated in the following example. Although for current calculations, the cut for only 10 years need be considered, this example shows how unequal age class distributions may be largely adjusted in one rotation without any considerable loss of production or drastic change in volume of cut.

White Pine--Carlton County, Minnesota--1949

Size class	Usual age range	Present distribution		Desirable distribution		Liquidation period (Years)
		Acres	Percent	Acres	Percent	
Large saw timber..	90 -	63	1.5	1,278	30	1.5
Small saw timber..	60 - 90	3,417	80.2	1,278	30	80.2
Pole timber.....	25 - 60	395	9.3	1,490	35	9.3
Restocking.....	0 - 25	384	9.0	213	5	9.0
Total.....	.....	4,259	100.0	4,259	100	100.0

[redacted] rotation -- (R) = 120 years, but under the shelterwood system a final cut will be made on an area at 100-year intervals, therefore the 100 years, the land rotation, will be used.

Harvest Range -- R_1 = 90 years to R_2 = 180 years

Large saw timber -- $n = P\left[\frac{R}{100}\right] = 1.5\left[\frac{100}{100}\right] = 1.5$ years

$n_1 = R_1 - Ar = 90 - 90 = 0$ years

$n_2 = R_2 - Ar = 180 - 90 = 90$ years

Since n is greater than n_1 and less than n_2, n years should be used.

Small saw timber -- At the end of 1.5 years, the small saw timber will be 61.5 to 91.5 years old.

$n = P\left[\frac{R}{100}\right] = 80.2\left[\frac{100}{100}\right] = 80.2$ years

$n_1 = R_1 - Ar = 90 - 91.5 = -1.5$ years

$n_2 = R_2 - Ar = 180 - 91.5 = 88.5$ years.

Therefore n = 80.2 years should be used. At the beginning of the period the working rotation age would be 91.5 years.

It would increase gradually until it became 141.7 years at the end of the 80.2 years. Theoretically the annual cut would increase slightly each year as the working rotation increased. Actually the volume of the cut could be controlled by the intermediate cuts made in stands that would not receive a final cut in the first 10-year period.

Pole timber -- At the end of 81.7 years (1.5 + 80.2 = 81.7), the pole timber would be 106.7 to 141.7 years old.

$$n = P\left[\frac{R}{100}\right] = 9.3\left[\frac{100}{100}\right] = 9.3 \text{ years}$$

$$n_1 = R_1 - Ar = 90 - 106.7 = -16.7 \text{ years}$$

$$n_2 = R_2 - Ar = 180 - 106.7 = 73.3 \text{ years}$$

Therefore, the 9.3 years should be used. The -16.7 years indicate that cutting could have begun 16.7 years earlier without going below the lower limit of the harvest range.

Restocking -- At the end of 91 years, the restocking stands would be 91 to 116 years old.

$$n = P\left[\frac{R}{100}\right] = 9.0\left[\frac{100}{100}\right] = 9.0 \text{ years}$$

$$n_1 = R_1 - Ar = 90 - 91 = -1 \text{ year}$$

$$n_2 = R_2 - Ar = 180 - 91 = 89 \text{ years}$$

Therefore the 9.0 years should be used. This would liquidate the existing stands in 100 years without violating any of the controls:

(1) Equal areas were cut over periodically.
(2) No timber under 90 years was cut nor any held beyond 180 years.
(3) Since equal areas of timber within the harvest range were cut over periodically, the yield would be reasonably even.

If the area cut over during the first 20 years had an adequate supply of advance reproduction, the adjustment would be complete and only 120-year-old timber would be cut after the first 100 years. If advance reproduction could not be expected during the first 20 years, but would be present thereafter as a result of regeneration cutting, it would mean cutting 100-year-old timber during the first 20 years of the second rotation. If advance reproduction cannot be expected, 120 years should be used in the area control formula.

Example 2.--Calculation of volume in the harvest cut is illustrated by the following example. Here the volume and growth in mature or near mature stands are considered for liquidation in the periods determined above and the annual cut for the first 10 years is computed.

White Pine--Carlton County, Minnesota--1949

Size class	Volume		Annual growth		n
	M bd.ft.	Cords	M bd.ft.	Cords	
Large saw timber	340	110	22	5	1.5
Small saw timber	11,780	17,370	969	278	80.2

$$\text{H.C. bd. ft.} = \frac{n}{10}\left[\frac{V}{n} + \frac{G}{2}\right] + \frac{10 - n}{10}\left[\frac{V^1 + g^1\left(\frac{n + 10}{2}\right)}{n^1}\right]$$

$$= .15\left[\frac{340}{1.5} + \frac{22}{2}\right] + .85\left[\frac{11{,}780 + 969\left(\frac{1.5 + 10}{2}\right)}{80.2}\right]$$

$$= .15\ (238) + .85\ (216)$$

$$= 218 \text{ M bd.ft. per year for 10 years}$$

$$\text{H.C. cords} = \frac{1.5}{10}\left[\frac{110}{1.5} + \frac{5}{2}\right] + \frac{8.5}{10}\left[\frac{17{,}370 + 278\left(\frac{1.5 + 10}{2}\right)}{80.2}\right]$$

= 212 cords per year for 10 years.

When computed for saw timber and pole timber, as above, the cut will be pro-rated to the species in the type according to the proportion of volume and growth by species shown in the inventory. If desired the cut for each individual species could be calculated by the formula.

Any cuts recommended in the field for the large saw timber, would be dropped since the entire volume will be in the harvest cut. The cut recommended in the field for the small saw timber would be discounted for that portion of the stand that will be harvested in the first 10 years. The amount recommended should be discounted by $\frac{10 - n}{n^1}$ or 10.6 percent, since 10.6 percent of the stand will be harvested within the first 10 years.

Application of cumulative basal area table (table 4).--Basal area per acre of twenty-three 8-inch trees tallied on 1/5-acre plot is approximately 40 square feet, i.e., 0.349 x 23 x 5 = 40. This is obtained directly from the table by referring to 8-inch d.b.h. block and reading in line marked "2" tens and column marked "3." Similarly, basal area per acre of six 4-inch trees tallied on 1/50-acre plot would be 26 square feet (line "0" tens and column "6" 4-inch d.b.h. block). The sum of the basal area by diameter classes is the total basal area per acre for the entire stand.

Total basal area per acre divided by the corresponding number of trees will give the average basal area per tree. The average stand d.b.h. (in inches) corresponding to this average basal area can be looked up in the block at the bottom of the table.

APPENDIX

Growing Stock Classification

Class A (Croptrees)

Trees of good risk and survival. These trees must meet all of the following specifications:

Position	--	Strong dominants and codominants of desirable species.
Crown	--	More than two-thirds filled; healthy, dense foliage.
Soundness	--	Relatively sound. Minor defects which will not seriously reduce the volume during the next cutting cycle are permitted.
Form	--	Good form, only slightly limby, crooked, forked, or bent. Windfirm--not subject to blowdown after a cutting.

Class B

Trees that cannot be easily grouped under Class A or Class C. They may be either left or removed, depending upon the growing stock level required.

Class C (Undesirable trees)

Trees of poor risk, which are not likely to survive through the cutting cycle. Any of the following conditions will put a tree in Class C:

Position	--	Suppressed, intermediate, or weak dominants or codominants.
Crown	--	Very poor, less than one-third filled, showing signs of regression.
Soundness	--	Poor risk trees, diseased, badly scarred or damaged, with major defects but at least 40 percent sound. Not likely to survive through the cutting cycle.
Form	--	Broken top, limby, crooked, bent, or badly forked.
Species	--	Undesirable species.

Class D (Cull trees)

Nonmerchantable trees, less than 40 percent of volume sound and merchantable.

Table 1.--Rotation and desirable size class distribution.

CENTRAL PINE DISTRICT - MINNESOTA

Type	[redacted] rotation	Harvest range	Desirable size class distribution (percent) and usual age ranges				
			Large saw timber	Small saw timber	Pole timber	Restocking	Cutting cycle
	Years	Years	Percent and years				Years
White pine.....	120	90-180	30 90-120	30 60-90	35 25-60	1/ 5 0-25	15
Red pine.....	120	90-180	30 90-120	30 60-90	35 25-60	1/ 5 0-25	15
Jack pine.....	60	45-80		16 50-60	42 25-50	42 0-25	10
Spruce-fir	60	45-80		17 50-60	33 30-50	50 0-30	10
Balsam fir subtype							
White spruce subtype	100	80-120		40 60-100	30 30-60	30 0-30	10
Black spruce							
Medium and... good site	80	60-120			44 45-80	56 0-45	20
Poor site....	140	80-180			57 60-140	43 0-60	20
Tamarack.....	100	80-160		20 80-100	35 45-80	45 0-45	15
Aspen							
Good site....	55	45-65		36 35-55	27 20-35	37 0-20	10
Medium site..	45	35-55		11 40-45	33 25-40	56 0-25	10
Poor site....	35	35-45			14 30-35	86 0-30	10
Paper birch...	80	60-100		12 70-80	50 30-70	38 0-30	10
Northern hardwoods.....							20
Bottom-land hardwoods....							20
Oak.....							15

1/ 0-20-year-old restocking will occur on an understory of large saw timber following regeneration cuts at 100 years.

Table 2.- Growing stock levels per acre.

A. JACK PINE

Average main stand diameter	Range in d.b.h. of main stand trees 1/	Optimum level 2/			Standard level 3/			Minimum level 4/		
		No. of trees	Spacing	Basal area	No. of trees	Spacing	Basal area	No. of trees	Spacing	Basal area
Inches	Inches	No.	Feet	Sq.ft.	No.	Feet	Sq.ft.	No.	Feet	Sq.ft.
2.0	1-4	1,450	5x6	32	870	7x7	19	600	8x9	13
2.5	1-4	1,330	5x7	46	790	7x8	27	565	8x9	19
3.0	1-6	1,205	6x6	59	705	8x8	35	520	9x9	25
3.5	2-6	1,060	6x7	70	622	8x9	42	470	9x10	32
4.0	2-8	905	7x7	79	555	9x9	49	427	10x10	37
5.0	2-8	655	8x8	89	435	10x10	59	340	11x12	46
6.0	2-10	483	9x10	95	343	11x11	67	279	12x13	55
7.0	4-10	368	11x11	99	273	12x13	73	227	14x14	61
8.0	4-12	288	12x13	101	221	14x14	77	187	15x16	65
9.0	4-16	231	13x14	102	182	15x16	80	155	17x17	68
10.0	6-16	190	15x15	104	153	17x17	83	132	18x18	72
12.0	6-16	134	18x18	105	111	20x20	87	97	21x21	76

1/ Trees falling within this range are considered main stand; smaller or larger trees are probably of a different age class.

2/ Optimum level - the amount of good growing stock (after cutting) required to produce maximum growth per acre. This level is recommended for intensive forestry.

3/ Standard level - the level of good growing stock which will insure satisfactory yields from the area. This is the preferred level for forest survey allowable cut.

4/ Minimum level - the level of good growing stock below which no cutting is recommended.

B. RED PINE

Average main stand diameter	Range in d.b.h. of main stand trees 1/	Optimum level 2/			Standard level 3/			Minimum level 4/		
		No. of trees	Spacing	Basal area	No. of trees	Spacing	Basal area	No. of trees	Spacing	Basal area
Inches	Inches	No.	Feet	Sq.ft.	No.	Feet	Sq.ft.	No.	Feet	Sq.ft.
2.0	1-4	1,450	5x6	32	950	7x7	21	700	8x8	15
2.5	1-4	1,360	6x6	48	840	7x7	28	640	8x8	22
3.0	1-6	1,250	6x6	61	780	7x8	38	582	8x9	28
3.5	2-6	1,160	5x7	79	690	8x8	46	530	9x9	36
4.0	2-8	1,050	6x7	91	610	8x9	53	477	9x10	42
5.0	2-8	802	7x8	109	485	9x10	66	388	10x11	53
6.0	2-10	587	8x9	115	381	10x11	75	312	12x12	61
7.0	4-10	439	10x10	117	308	12x12	82	255	13x13	68
8.0	4-12	338	11x12	118	252	13x13	88	209	14x15	73
9.0	4-16	269	13x13	119	207	14x15	91	173	15x17	76
10.0	6-16	219	14x14	120	175	15x16	95	146	17x18	80
12.0	6-16	153	17x17	120	127	18x19	98	107	20x20	84
14.0	8-22	113	19x20	120	97	21x21	103	79	23x24	84
16.0	10-26	86	22x23	120	75	24x24	104	60	27x27	84

1/ Trees falling within this range are considered main stand; smaller or larger trees are probably of a different age class.

2/ Optimum level - the amount of good growing stock (after cutting) required to produce maximum growth per acre. This level is recommended for intensive forestry.

3/ Standard level - the level of good growing stock which will insure satisfactory yields from the area. This is the preferred level for forest survey allowable cut.

4/ Minimum level - the level of good growing stock below which no cutting is recommended.

C. WHITE PINE

Average main stand diameter	Range in d.b.h. of main stand trees 1/	Optimum level 2/			Standard level 3/			Minimum level 4/		
		No. of trees	Spacing	Basal area	No. of trees	Spacing	Basal area	No. of trees	Spacing	Basal area
Inches	Inches	No.	Feet	Sq.ft.	No.	Feet	Sq.ft.	No.	Feet	Sq.ft.
2.0	1-4	1,700	5x5	38	1,040	6x7	23	800	7x8	18
2.5	1-4	1,550	5x6	53	938	6x8	32	720	7x9	24
3.0	1-6	1,410	5x6	69	836	7x7	41	660	8x8	32
3.5	2-6	1,270	6x6	85	746	7x8	50	597	8x9	40
4.0	2-8	1,120	6x7	98	670	8x8	58	532	9x9	46
5.0	2-8	810	7x8	110	530	9x9	72	420	10x10	57
6.0	2-10	590	8x9	116	418	10x10	82	337	11x12	66
7.0	4-10	455	10x10	121	337	11x12	90	272	13x13	73
8.0	4-12	355	12x12	124	274	13x13	96	222	14x14	78
9.0	4-16	290	12x13	128	227	14x14	100	185	15x15	82
10.0	6-16	236	13x14	129	190	15x15	104	156	16x17	85
12.0	6-16	160	16x17	130	138	18x18	108	114	19x20	90
14.0	8-22	121	19x19	130	104	20x21	111	88	22x22	94
16.0	10-26	93	21x22	130	82	23x23	114	69	25x25	96

1/ Trees falling within this range are considered main stand; smaller or larger trees are probably of a different age class.

2/ Optimum level - the amount of good growing stock (after cutting) required to produce maximum growth per acre. This level is recommended for intensive forestry.

3/ Standard level - the level of good growing stock which will insure satisfactory yields from the area. This is the preferred level for forest survey allowable cut.

4/ Minimum level - the level of good growing stock below which no cutting is recommended.

D. SPRUCE AND BALSAM FIR

Average main stand diameter	Range in d.b.h. of main stand trees 1/	Optimum level 2/			Standard level 3/			Minimum level 4/		
		No. of trees	Spacing	Basal area	No. of trees	Spacing	Basal area	No. of trees	Spacing	Basal area
Inches	Inches	No.	Feet	Sq.ft.	No.	Feet	Sq.ft.	No.	Feet	Sq.ft.
2.0	1-4	2,000	4x5	44	1,450	5x6	32	800	7x8	18
2.5	1-4	1,750	5x5	60	1,200	6x6	41	720	7x9	24
3.0	1-6	1,540	5x6	75	1,020	6x7	50	660	8x8	32
3.5	2-6	1,350	5x6	90	870	7x7	58	597	8x9	40
4.0	2-8	1,160	6x6	101	760	7x8	66	532	9x9	46
5.0	2-8	840	7x7	114	585	8x9	80	420	10x10	57
6.0	2-10	620	8x9	122	460	9x10	90	337	11x12	66
7.0	4-10	470	9x10	125	368	11x11	99	272	13x13	73
8.0	4-12	370	11x11	129	295	12x12	103	222	14x14	78
9.0	4-16	295	12x12	130	242	13x14	107	185	15x15	82
10.0	6-16	241	13x14	131	200	15x15	109	156	16x17	85

1/ Trees falling within this range are considered main stand; smaller or larger trees are probably of a different age class.

2/ Optimum level - the amount of good growing stock (after cutting) required to produce maximum growth per acre. This level is recommended for intensive forestry.

3/ Standard level - the level of good growing stock which will insure satisfactory yields from the area. This is the preferred level for forest survey allowable cut.

4/ Minimum level - the level of good growing stock below which no cutting is recommended.

E. ASPEN

Average main stand diameter	Range in d.b.h. of main stand trees 1/	Optimum level 2/			Standard level 3/			Minimum level 4/		
		No. of trees	Spacing	Basal area	No. of trees	Spacing	Basal area	No. of trees	Spacing	Basal area
Inches	Inches	No.	Feet	Sq.ft.	No.	Feet	Sq.ft.	No.	Feet	Sq.ft.
2.0	1-4	700	8x8	15	500	9x10	11	405	10x11	9
2.5	1-4	660	8x8	22	475	9x10	16	383	10x11	13
3.0	1-6	625	8x9	31	437	10x10	21	353	11x11	17
3.5	2-6	565	9x9	38	403	10x11	27	327	11x12	22
4.0	2-8	530	9x9	46	368	11x11	32	302	12x12	26
5.0	2-8	425	10x10	58	304	12x12	41	254	13x13	35
6.0	2-10	335	11x12	66	250	13x13	49	211	14x14	41
7.0	4-10	268	12x13	72	206	14x15	55	176	15x16	45
8.0	4-12	218	14x14	76	172	16x16	60	148	17x18	52
9.0	4-16	179	15x16	79	144	17x18	64	125	19x19	56
10.0	6-16	150	18x18	82	122	19x19	67	107	20x20	58
12.0	6-16	109	20x20	85	90	22x22	70	80	23x23	62

1/ Trees falling within this range are considered main stand; smaller or larger trees are probably of a different age class.

2/ Optimum level - the amount of good growing stock (after cutting) required to produce maximum growth per acre. This level is recommended for intensive forestry.

3/ Standard level - the level of good growing stock which will insure satisfactory yields from the area. This is the preferred level for forest survey allowable cut.

4/ Minimum level - the level of good growing stock below which no cutting is recommended.

F. OAK

Average main stand diameter	Range in d.b.h. of main stand trees 1/	Optimum level 2/			Standard level 3/			Minimum level 4/		
		No. of trees	Spacing	Basal area	No. of trees	Spacing	Basal area	No. of trees	Spacing	Basal area
Inches	Inches	No.	Feet	Sq.ft.	No.	Feet	Sq.ft.	No.	Feet	Sq.ft.
2.0	1-4	900	7x7	20	574	8x9	13	405	10x11	9
2.5	1-4	840	7x7	28	534	9x9	18	383	10x11	13
3.0	1-6	785	7x8	38	485	9x10	24	353	11x11	17
3.5	2-6	723	7x9	48	445	10x10	30	327	11x12	22
4.0	2-8	660	8x8	57	403	10x11	35	302	12x12	26
5.0	2-8	525	9x9	72	327	11x12	45	254	13x13	35
6.0	2-10	410	10x11	80	267	13x13	52	211	14x14	41
7.0	4-10	317	12x12	85	219	14x14	58	176	15x16	45
8.0	4-12	252	13x13	88	181	15x16	63	148	17x18	52
9.0	4-16	206	14x15	91	150	18x18	66	125	19x19	56
10.0	6-16	172	16x16	94	127	19x19	69	107	20x20	58
12.0	6-16	122	19x19	96	93	22x22	73	80	23x23	62
14.0	8-22	91	22x22	97	71	25x25	76	60	27x27	64
16.0	10-26	71	25x25	99	56	28x28	79	47	30x30	66

1/ Trees falling within this range are considered main stand; smaller or larger trees are probably of a different age class.

2/ Optimum level - the amount of good growing stock (after cutting) required to produce maximum growth per acre. This level is recommended for intensive forestry.

3/ Standard level - the level of good growing stock which will insure satisfactory yields from the area. This is the preferred level for forest survey allowable cut.

4/ Minimum level - the level of good growing stock below which no cutting is recommended.

G. SECOND-GROWTH HARDWOODS 1/

Size class	D.B.H. class	Optimum level		Standard level		Minimum level	
		No. of trees	Basal area	No. of trees	Basal area	No. of trees	Basal area
	Inches	No.	Sq.ft.	No.	Sq.ft.	No.	Sq.ft.
Restocking	2-4	1,200	42	900	32	650	23
Pole timber	2-4	500	13	385	10	310	8
	6-10	295	57	205	40	125	24
			70		50		32
Large pole timber	2-4	270	9	210	7	150	5
	6-10	300	70	255	60	158	37
	12+	5	5	3	3	2	1
			84		70		43
Small saw timber	2-4	120	4	100	3	80	3
	6-10	160	39	130	32	90	22
	12+	35	49	30	42	17	23
			92		77		48
Large saw timber	2-4	100	3	100	3	65	2
	6-10	70	20	63	17	48	13
	12+	50	70	41	60	27	35
			93		80		50

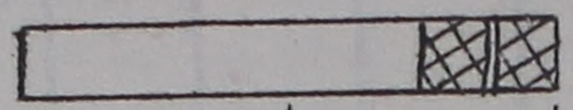
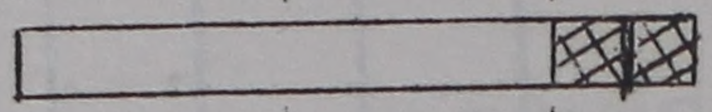
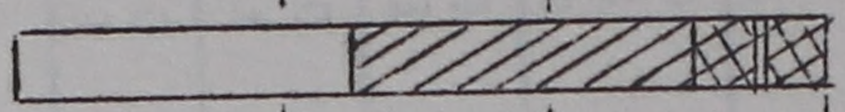
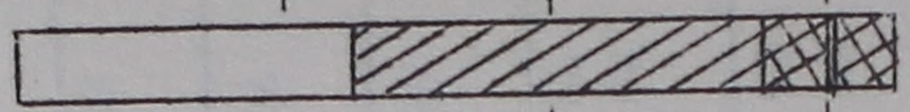
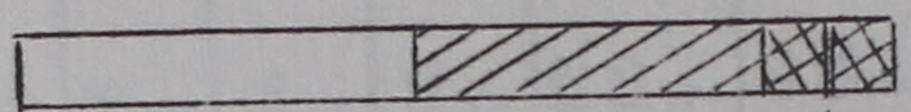
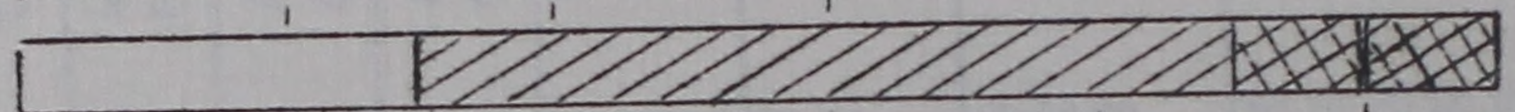
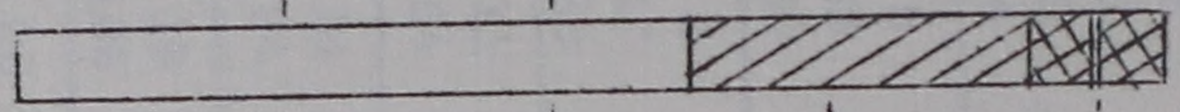
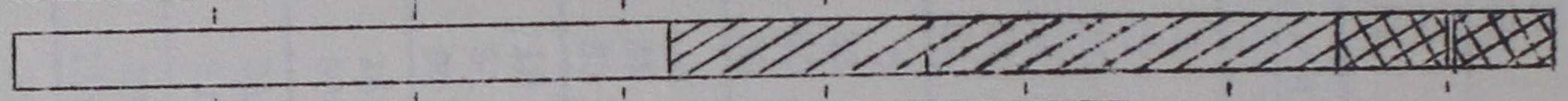
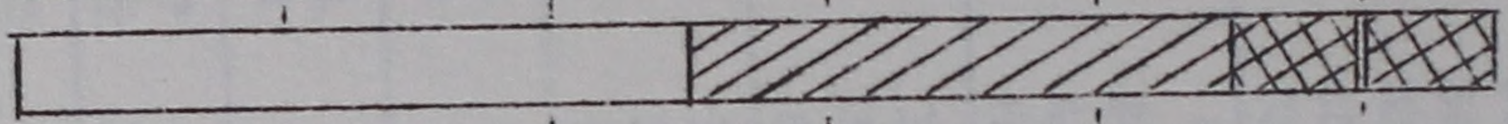
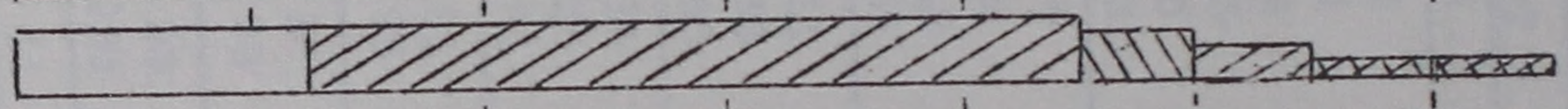
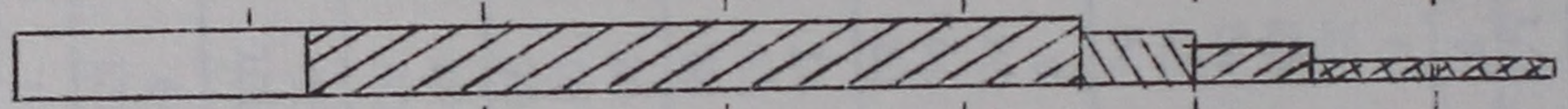
1/ Includes northern and bottomland hardwoods.

H. OLD-GROWTH HARDWOODS 1/

D.B.H. class	Optimum level		Standard level		Minimum level		No. of bd. ft. per sq. ft. of basal area (Int. ¼ net)
	No. of trees	Basal area	No. of trees	Basal area	No. of trees	Basal area	
Inches	No.	Sq.ft.	No.	Sq.ft.	No.	Sq.ft.	
2-4	100	3	100	3	65	2	-
6-8	45	10	45	10	35	8	-
8-10	25	10	18	7	13	5	-
	170	23	163	20	113	15	-
12-14	30	25	24	20	18	15	90
16-20	15	25	12	20	6	10	125
22+	5	20	5	20	3	10	120
	50	70	41	60	27	35	111
All	220	93	204	80	140	50	-

1/ Includes northern and bottomland hardwoods.

Table 3.- System of cuttings for even-aged types.

Type and site		Age and kind of cut	Primary product
Aspen	- Poor		Pulpwood
	Medium		Pulpwood
	Good		Sawlog
Jack pine	- Medium		Both
Spruce-fir (fir)	- Medium		Pulpwood
(white spruce)	- Medium		Both
Spruce (Black)	- Medium		Pulpwood
	Poor		Pulpwood
Tamarack	- Medium		Pulpwood
Red pine	- Medium		Sawlog
White pine	- Medium		Sawlog

Salvage cuts and unmerchantable thinnings

Regeneration cut (shelterwood)

Intermediate cuttings

Final cut (center line indicates rotation age)

Table 4.--Cumulative basal area table. Lake States Forest Experiment Station 1949

NUMBER OF TREES PER PLOT - 1/50 Acre

D.B.H.	Tons	0	1	2	3	4	5	6	7	8	9
Inches		Basal area - square feet per acre									
2	0		1	2	3	4	6	7	8	9	10
	1	11	12	13	14	15	17	18	19	20	21
	2	22	23	24	25	26	28	29	30	31	32
4	0		4	9	13	17	22	26	30	35	39
	1	44	48	52	57	61	65	70	74	78	83

NUMBER OF TREES PER PLOT - 1/5 Acre

D.B.H.	Tons	0	1	2	3	4	5	6	7	8	9
6	0		1	2	3	4	5	6	7	8	9
	1	10	11	12	13	14	15	16	17	18	19
	2	20	21	22	23	24	25	25	26	27	28
	3	29	30	31	32	33	34	35	36	37	38
	4	39	40	41	42	43	44	45	46	47	48
	5	49	50	51	52	53	54	55	56	57	58
8	0		2	3	5	7	9	10	12	14	16
	1	17	19	21	23	24	26	28	30	31	33
	2	35	37	38	40	42	44	45	47	49	51
	3	52	54	56	58	59	61	63	65	66	68
10	0		3	5	8	11	14	16	19	22	25
	1	27	30	33	35	38	41	44	46	49	52
	2	55	57	60	63	65	68	71	74	76	79
12	0		4	8	12	16	20	24	27	31	35
	1	39	43	47	51	55	59	63	67	71	75
	2	79	82	86	90	94	98	102	106	110	114
14	0		5	11	16	21	27	32	37	43	48
	1	53	59	64	69	75	80	86	91	96	102
16	0		7	14	21	28	35	42	49	56	63
	1	70	77	84	91	98	105	112	119	126	133
18	0		9	18	27	35	44	53	62	71	80
	1	88	97	106	115	124	133	141	150	159	168
20			11	22	33	44	55	65	76	87	98

NUMBER OF TREES PER PLOT - 1/5 Acre

D.b.h.	1	2	3	D.b.h.	1	2	3	D.b.h.	1	2	3
Inches	Area per acre			Inches	Area per acre			Inches	Area per acre		
22	13	26	40	32	28	56	84	42	48	96	144
24	16	31	47	34	32	63	95	44	53	106	158
26	18	37	55	36	35	71	106	46	58	115	173
28	21	43	64	38	39	79	118	48	63	126	189
30	25	49	74	40	44	87	131	50	68	136	205

DIAMETER CORRESPONDING TO AVERAGE BASAL AREA

Av. B.A./Tree	.022	.034	.049	.067	.087	.136	.196	.267	.349
Av. D.B.H.	2.0	2.5	3.0	3.5	4.0	5.0	6.0	7.0	8.0
Av. B.A./Tree	.442	.545	.660	.785	.922	1.069	1.227	1.396	1.576
Av. D.B.H.	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0